AFRL-RX-TY-TP-2008-4554

CONTAMINATION CONTROL AREA – AIRLOCK – TOXIC FREE AREA PROCESS ANALYSIS (BRIEFING CHARTS)

Bruce J. Nielsen
Air Force Research Laboratory

MAY 2007

Interim Report for 1 April 2006 to 1 January 2007

Presented at the bi-annual meeting of the DOD Joint Committee on Tactical Shelters (JOCOTAS) and Rigid Wall and Soft Wall Shelter Industry and Exhibition, Panama City Beach, FL 30 April – 2 May 2007.

AIRBASE TECHNOLOGIES DIVISION
MATERIALS AND MANUFACTURING DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
139 BARNES DRIVE, SUITE 2
TYNDALL AIR FORCE BASE, FL 32403-5323

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06-MAY-2007	Conference Presentation	01-APR-2006 -- 01-JAN-2007

4. TITLE AND SUBTITLE

Contamination Control Area - Airlock - Toxic Free Area Process Analysis (BRIEFING CHARTS)

5a. CONTRACT NUMBER

F08637-03-C-6006

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

62384B

6. AUTHOR(S)

Nielsen, Bruce J.

5d. PROJECT NUMBER

4915

5e. TASK NUMBER

L2

5f. WORK UNIT NUMBER

Q230LA63

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory
Materials and Manufacturing Directorate
139 Barnes Drive, Suite 2
Tyndall Air Force Base, FL 32403-5323

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory
Materials and Manufacturing Directorate
139 Barnes Drive, Suite 2
Tyndall Air Force Base, FL 32403-5323

10. SPONSOR/MONITOR'S ACRONYM(S)

AFRL/RXQL

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

AFRL-RX-TY-TP-2008-4554

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A: Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

Ref AFRL/RXQ Public Affairs Case # 07-030. Document contains color images. Presented at DOD Joint Committee on Tactical Shelters (JOCOTAS) and Rigid Wall and Soft Wall Shelter Industry and Exhibition, Panama City Beach, FL 30 Apr-2 May 2007.

14. ABSTRACT

Collective Protection (COLPRO) systems provide unencumbered, long term personnel protection and have capability for ingress/egress of personnel as they process out (doff) and into (donn) Individual Protection Equipment (IPE). To enter COLPRO systems, strict processes are enforced to allow safe entry as well as maintain the integrity of the Toxic Free Area (TFA). Normally, personnel would process through an outside Contamination Control Area (CCA) where decontamination crews identify any gross liquid contamination and direct decontamination appropriately. Personnel then carefully remove their outer protective garments, with the exception of the mask, hood, and gloves and enter the protected entrance or Airlock (A). While in the airlock, air purging removes airborne vapor and aerosol contamination, and personnel conduct the final decontamination steps to clean or contain mask, hood, and gloves. This process of moving personnel through a CCA, Airlock, and into a Toxic Free Area will be referred to as the **CCA/A/TFA Process.** The objective of this CCA/A/TFA Process Analysis is to analyze current procedures, develop a CCA/A/TFA Process model, and make recommendations to provide personnel an "acceptable level of protection" (contamination level below contamination control limits) over a specified time interval while maintaining a "throughput" (personnel processed per time interval) sufficient to meet mission/force protection requirements.

15. SUBJECT TERMS

collective protection, airlock, contamination control area, toxic free area, decontamination

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Bruce Nielsen
U	U	U	UU	34	19b. TELEPHONE NUMBER *(Include area code)*

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Good Morning!

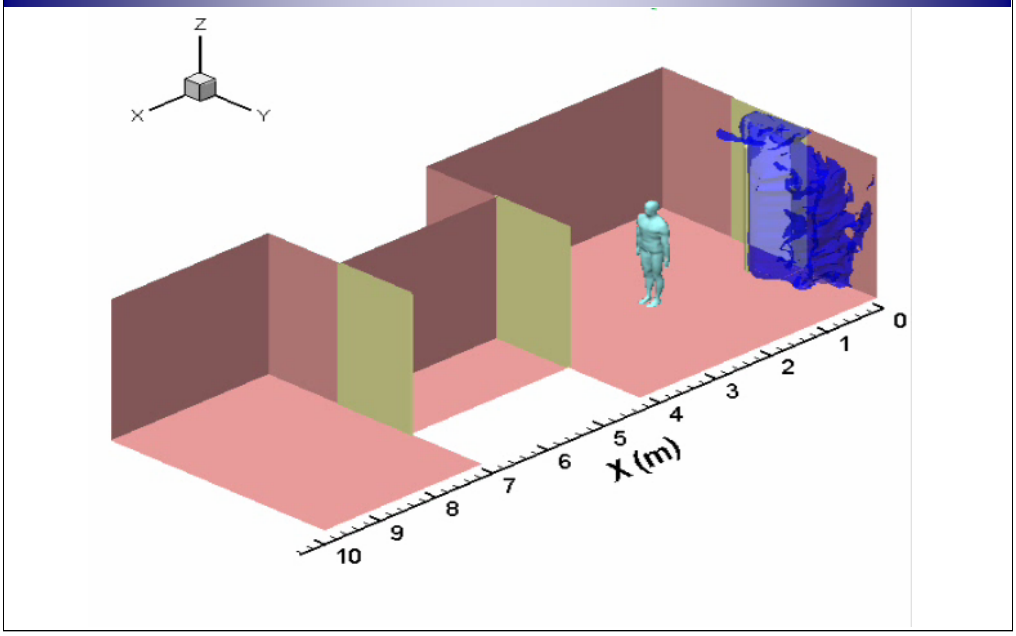
In my past position as DTRA COLPRO Thrust Manager I heard many discussions regarding CCA/A/TFA Processing, usually focusing on one component of the process by many of the capability areas to include: Individual Protection, DECON, Collective Protection, Detection, Threat Agent Science and Modeling & Simulation.

But no one really was looking at the whole process.

I saw many proposals for airlocks citing that they are a “bottleneck” to COLPRO ingress/egress while others looked at the CCA process as the most cumbersome process

A better understanding of the CCA/A/TFA Process as a system was needed.

Contamination Control Area, Airlock and Toxic Free Area (CCA/A/TFA) Process Analysis



This project attempts to better understand that process and then to identify best approaches for providing throughput while minimizing contaminant transport

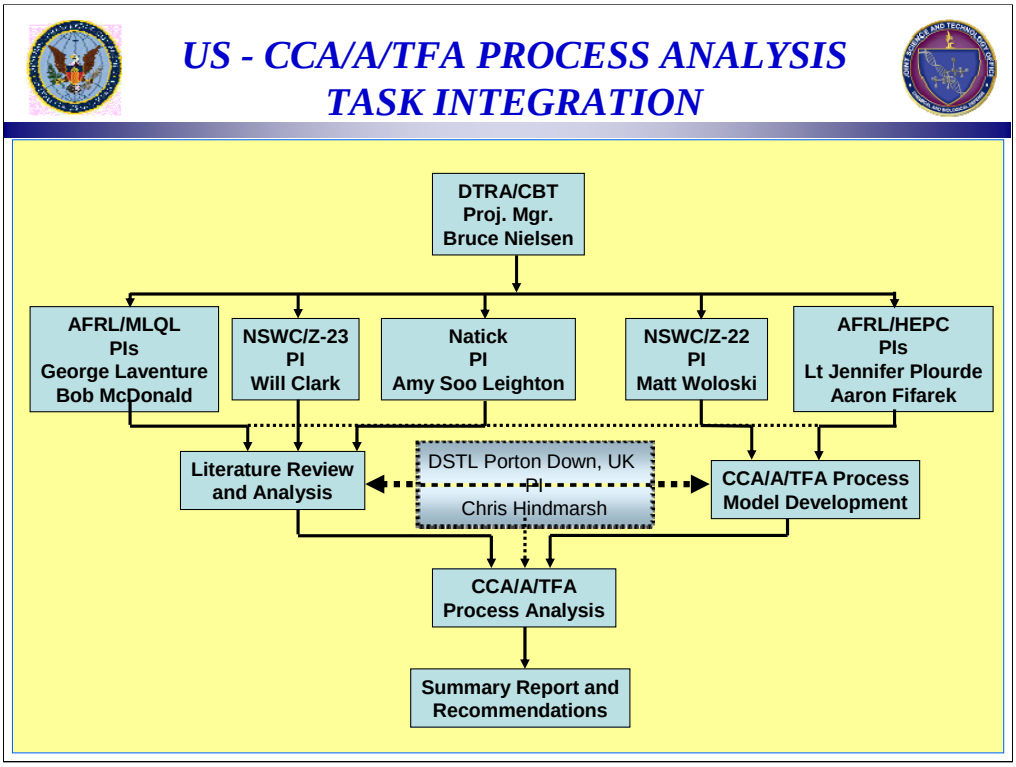
Contamination Control Area, Airlock and Toxic Free Area (CCA/A/TFA) Process Analysis

Objectives

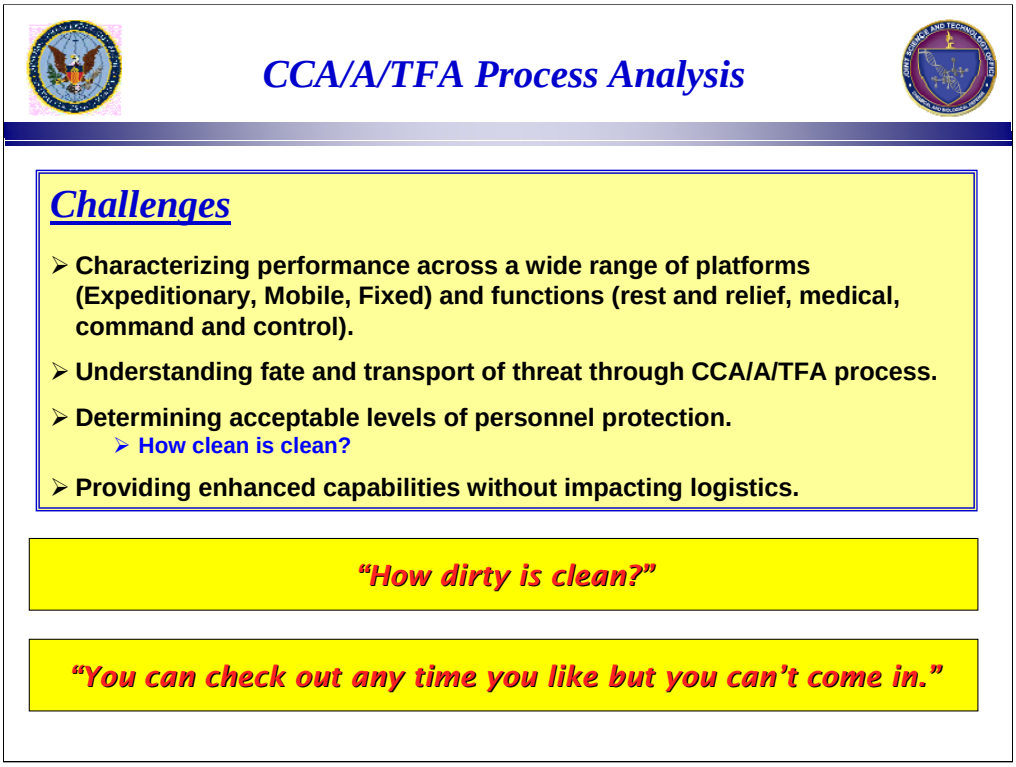
- **Establish an Integrated Process Team (IPT) to perform an analysis of CCA/A/TFA process.**
- **Develop comprehensive knowledge base of CCA/A/TFA process to include characterization of transport and fate of agents to minimize contamination and exposure levels.**
- **Apply current modeling capabilities to perform parametric analyses of CCA/A/TFA processes.**

We formed a joint Air Force, Navy and Army team to develop a knowledge base and initial model of the process.

Knowledge and modeling capability will focus on mitigation of contaminant transport through process and the resulting exposure in the TFA by personnel.



Acknowledge team of individuals



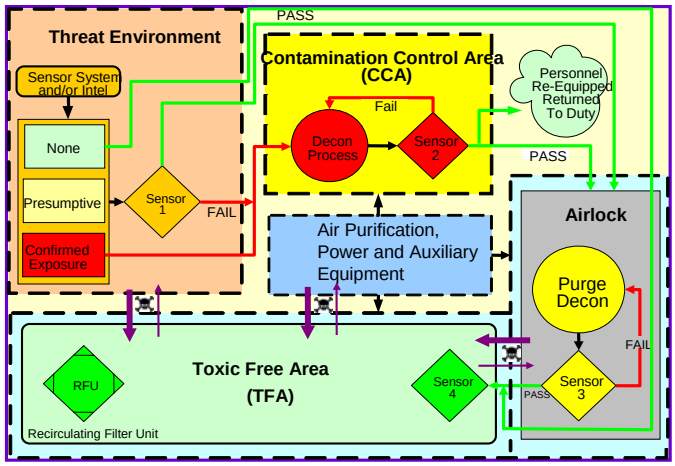
One problem is that there is not one standard CCA/A/TFA system or process.

Also modeling contaminant transport

And the complex question of "How clean is clean?"

Or from our perspective: "How dirty is clean?" and a worse case conclusion of: To paraphrase "Eagles – Hotel California" "You can check out any time you like but you can't come in."

CCA/A/TFA Process Flow Diagram

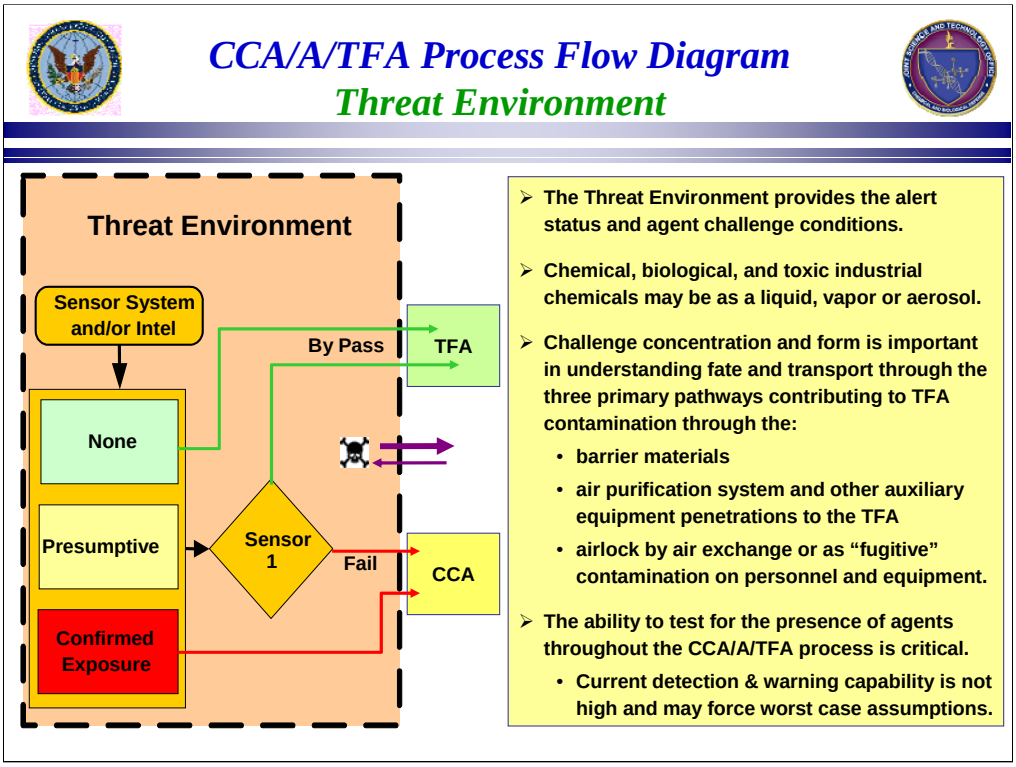


To maintain and improve the protected environment in the TFA, the flow of personnel and equipment and the fate and transport of threat agents must be understood.

Five critical areas need to be addressed:

- **Threat Environment**
- **CCA**
- **Airlock**
- **TFA**
- **Air Purification and Auxiliary Equipment**

Goal was to model flow of personnel and transport of contaminants through the system that is broken into five areas



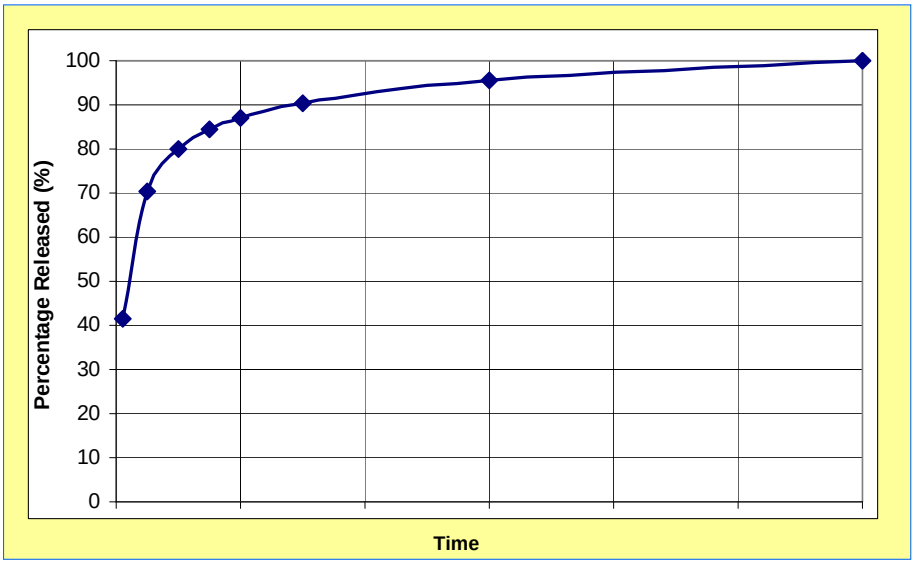
The Threat Environment provides challenge and alert levels

CBRN TIC/TIM as liquid, vapor, aerosol

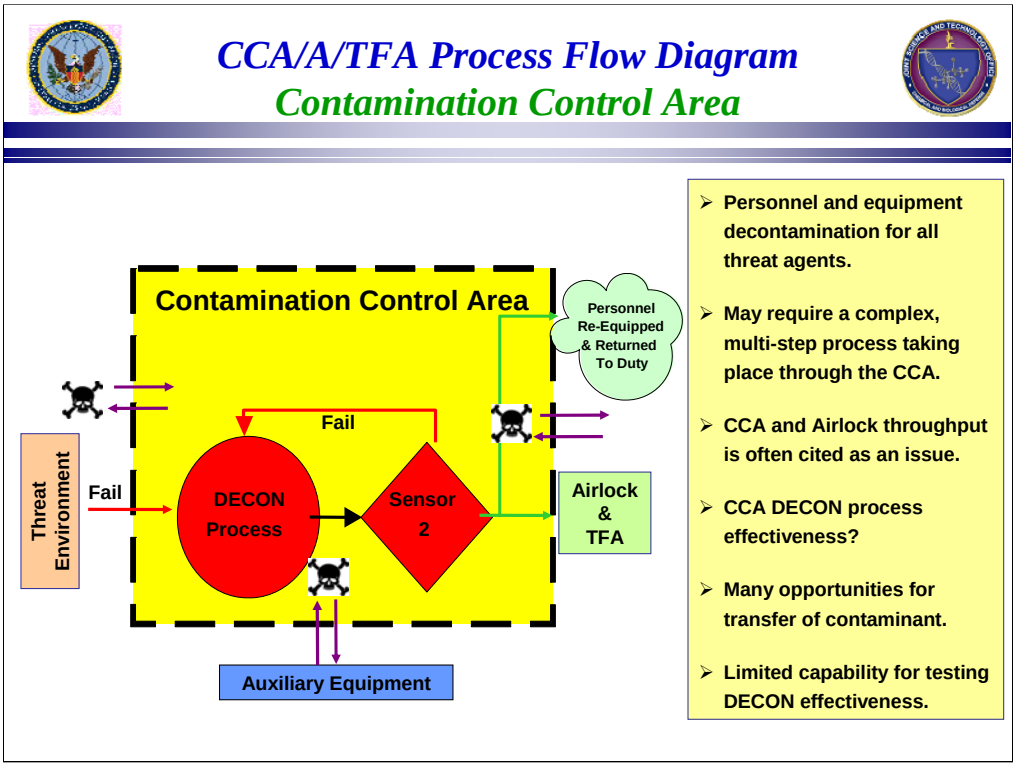
Three primary paths into TFA

Lack of monitoring may risk TFA contamination or force worst case assumption (DECON everyone)

Rate of Agent Desorption

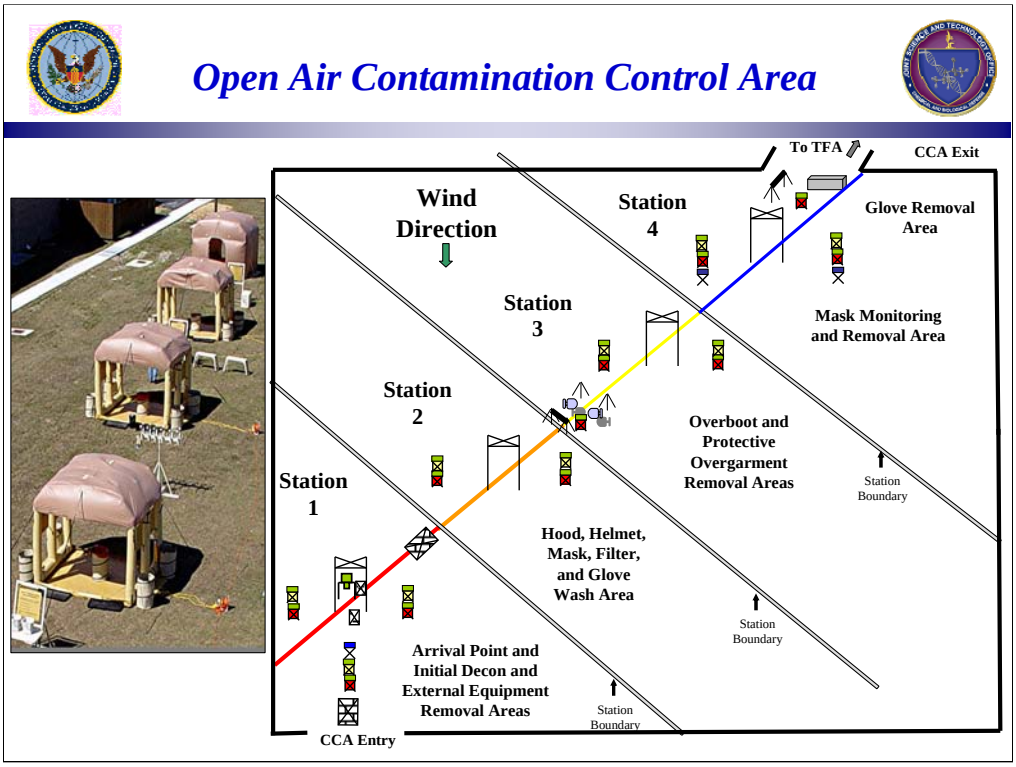


Part of our required data was to understand Adsorption/Desorption and Deposition/Re-Aerosolization



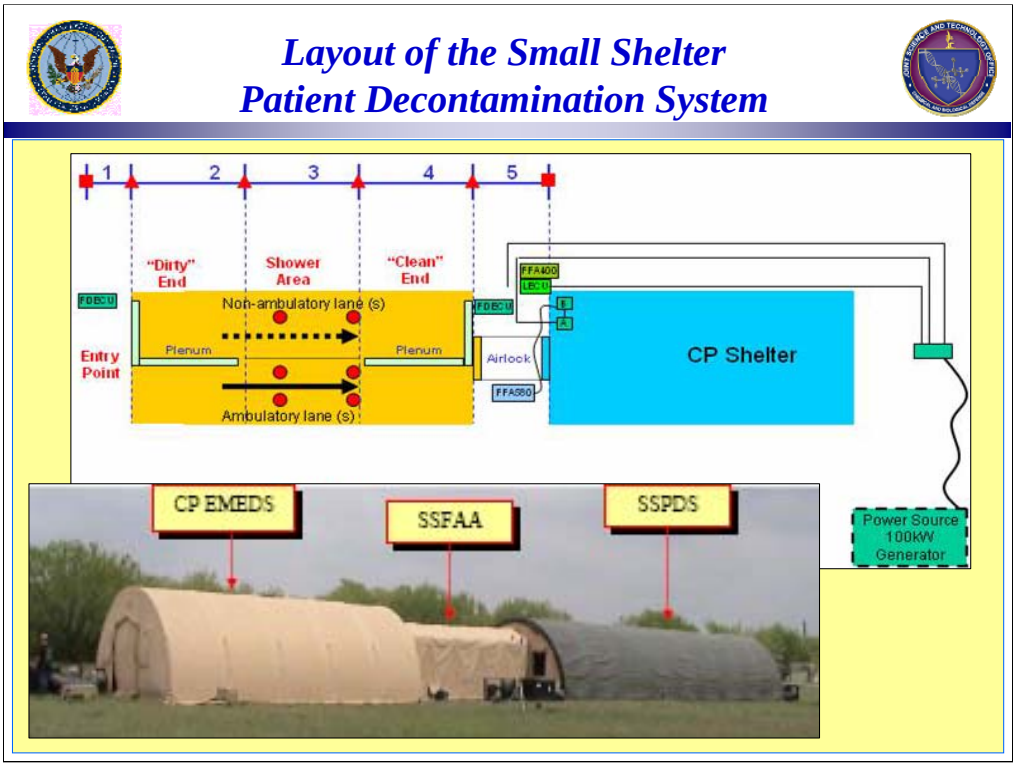
As alluded earlier having monitoring technology for assessing need to decontaminate would be advantageous as this is the most time consuming step (bottleneck) and where much contaminant transfer occurs.

Those questions of "How clean is clean?" and "How dirty is clean "?



An Open air CCA

The JECP CDD requires ingress/egress in a contaminated environment and may have limited CCA capabilities



A closed CCA developed by Air Force for EMEDS (Expeditionary Medical Support)

Provides controlled environment but is logistical burden

Swedish Demonstration

Toxic Trip 2005, Zaragosa Air Base, Spain

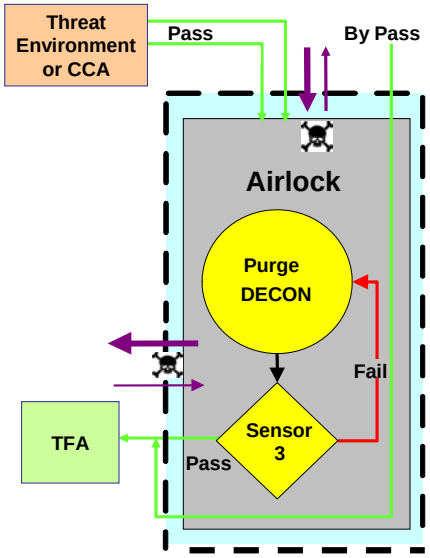
CW Agent Contamination Test Cabinet Aircrew Processing System

- Infrared heaters that rapidly heat the enclosure to ~70°C
- 90 second processing/sample time
- CW agent detector (AP2C monitor)

An approach for assessing whether to DECON or not (CCA Triage).

CCA/A/TFA Process Flow Diagram
Airlock

- The Airlock has the primary function of controlling vapor and other airborne contaminants from entering the TFA
  - Maintaining the TFA overpressure.
- The Airlock was originally design around a chemical challenge
  - Assumption that personnel and equipment are "clean."
- The ability to test for threat agents to determine if personnel and equipment are clean enough to safely enter the TFA may be deficient.
- Potential for fugitive contamination
  - Airlock may provide the final DECON step.



Airlocks maintain over-pressure and control transport of airborne contaminants.

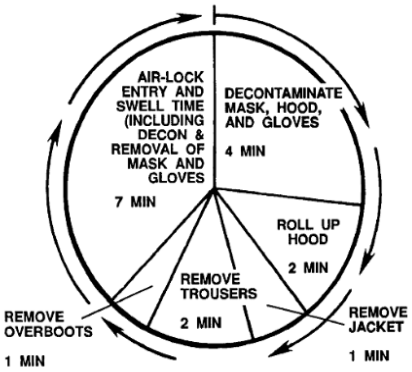
"How dirty is clean?"

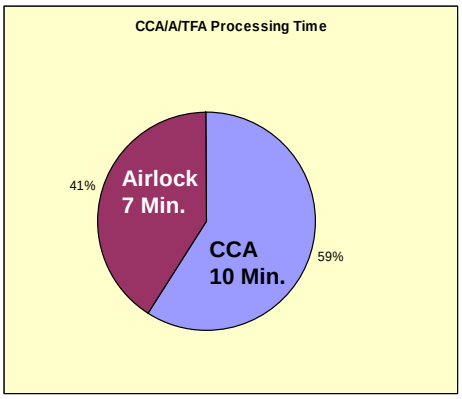
Airlock importance and need for enhancements increasing as JECP CDD may require final doffing and DECON in airlock

Entry Process from Army FM 3-4

U.S. Army Field Manual 3-4 recommends that commanders estimate 17 minutes for each person to complete the CCA/A/TFA process.

Table 6-5. Entry process times.





Entry Process from Field Manual 3-4

Airlock Process to provide three-log purge of airborne contaminants

The Contamination Control Area and Airlock process takes about 17 minutes

This may be optimistic, especially for the CCA processing of air crews

Airlocks

M28 Protective Entrance

CBPSS endwall with integral litter and ambulatory airlocks

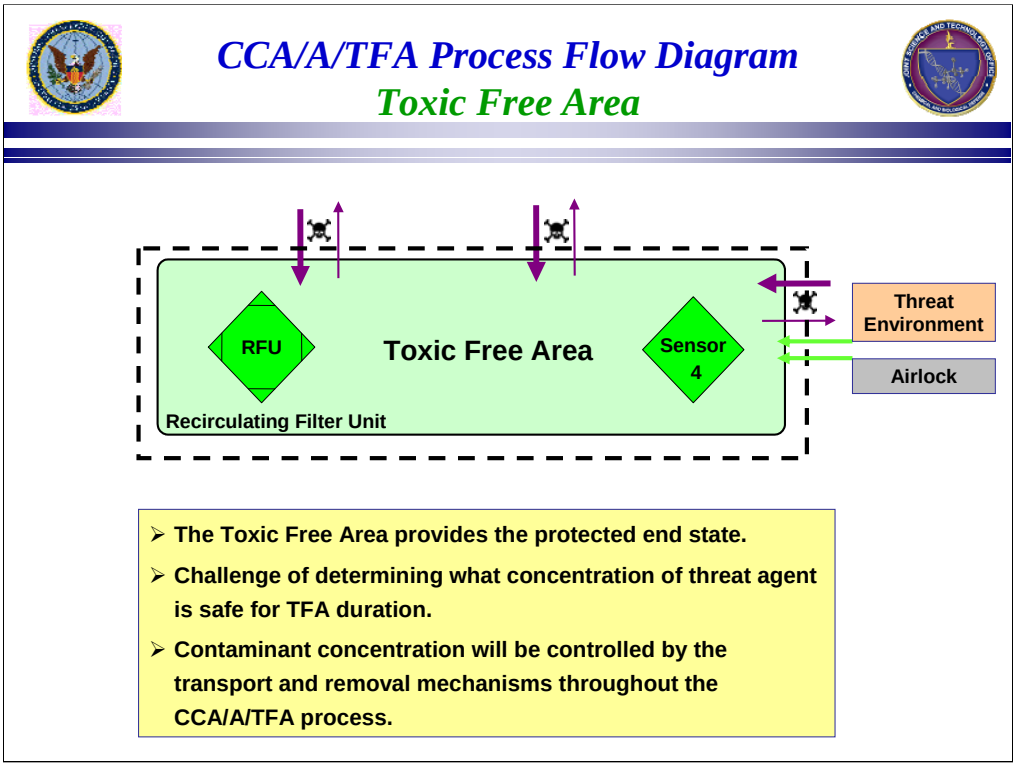
Bump-Through-Door Airlock

BTDA (side view) with FFA 580 installed

Some examples of single person, litter patient, and multi-person airlocks.

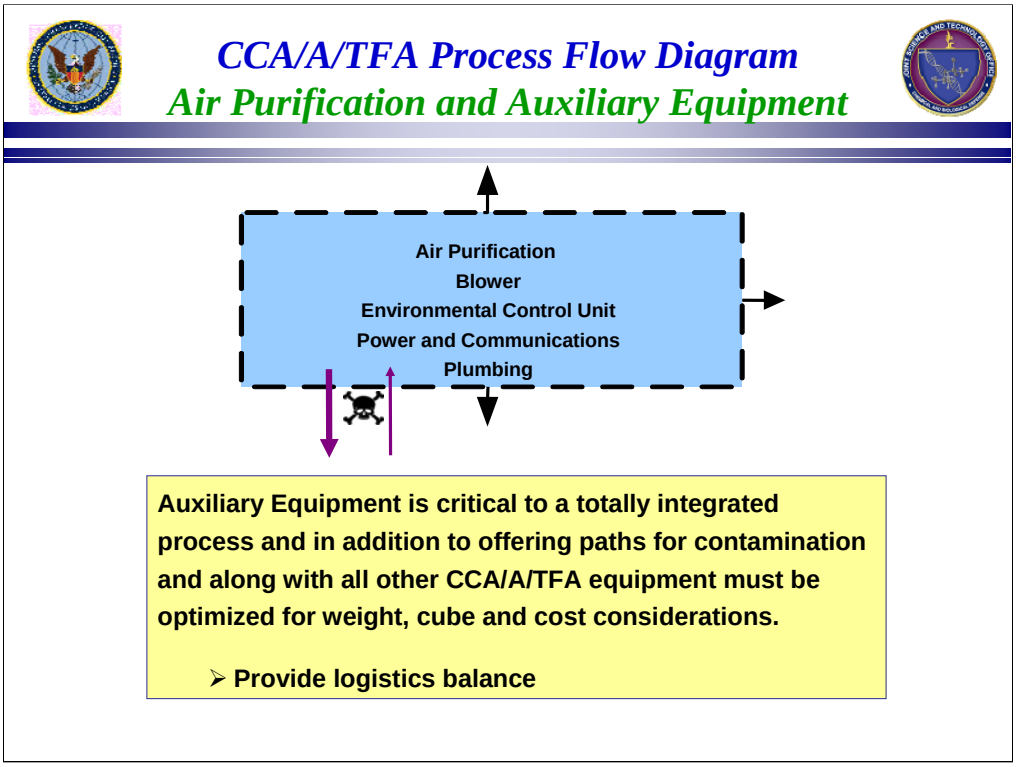
One issue is the volume and the rule of thumb requiring six air exchanges to provide a 3-log reduction in airborne contamination

The BTDA is logistically burdensome

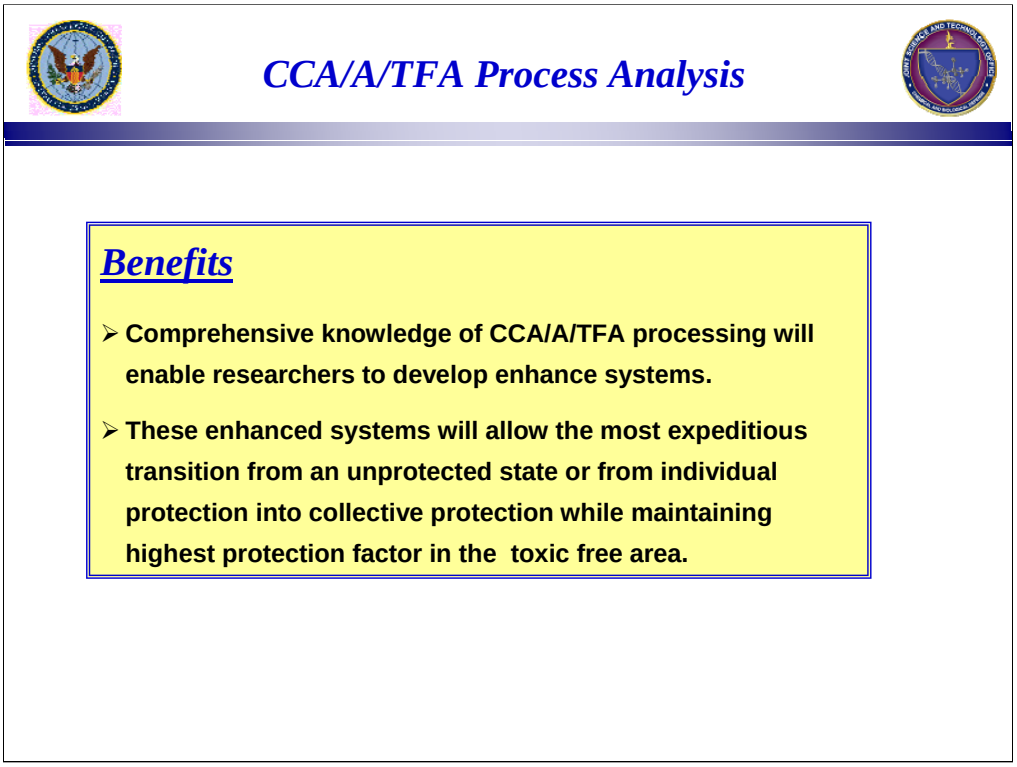


The issue in the TFA is contaminant concentration and duration of stay with respect to current toxicity standards and low level exposure studies.

Use knowledge to mitigate exposure.

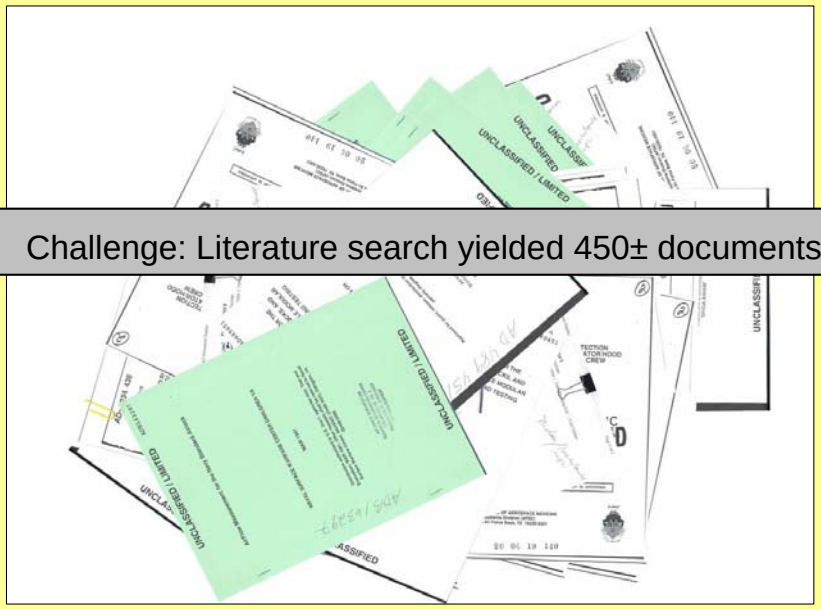


The air purification systems is critical source and sink for contamination as well as any other penetration to the TFA.

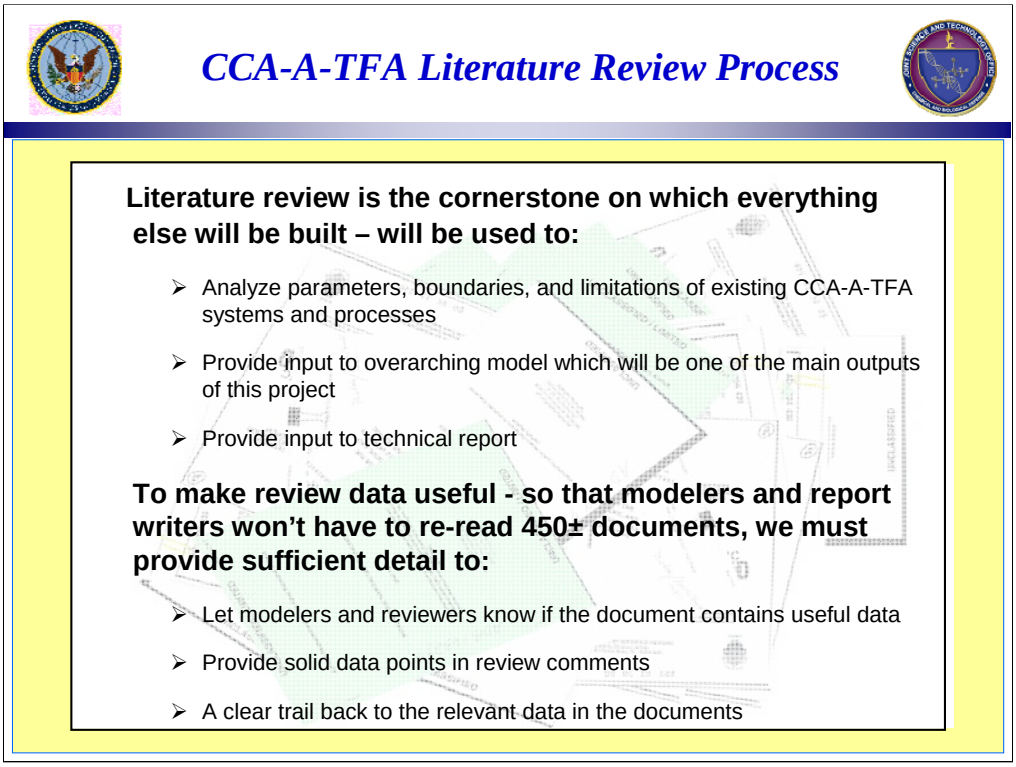


The analysis focusing on identifying "weak links" will help direct system improvements.

CCA-A-TFA Literature Review Process



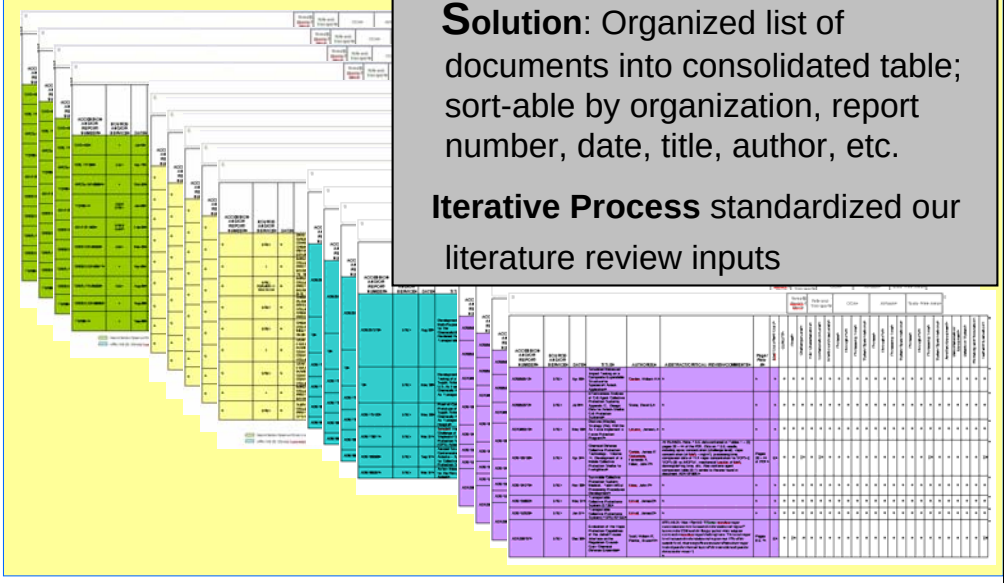
First objective was to gather information by PI from each service performing literature search and review



The knowledge from review was basis for modeling and reference source for final report

To be more useful the information was arranged in an spreadsheet by key terms

CCA-A-TFA Literature Review Process



Solution: Organized list of documents into consolidated table; sort-able by organization, report number, date, title, author, etc.

Iterative Process standardized our literature review inputs

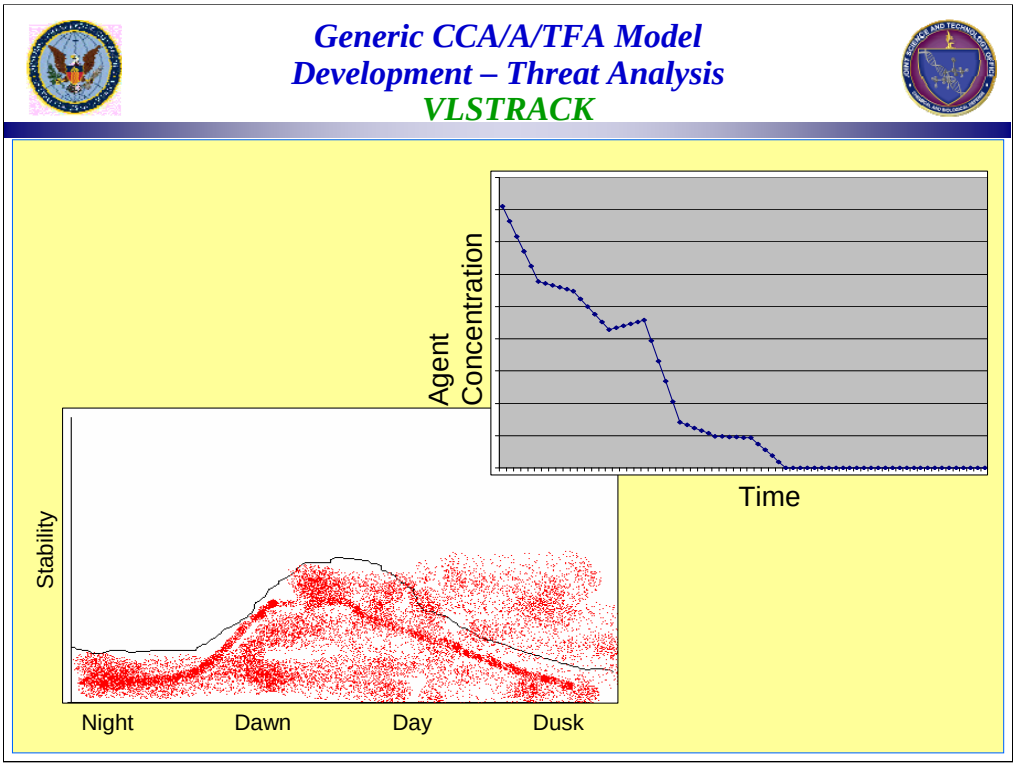
Product was a spreadsheet database with review comments

CCA-A-TFA Literature Review Process

ACCESSION AND/OR REPORT NUMBER	SOURCE AND/OR SERVICE	DATE	TITLE	AUTHOR(S)	ABSTRACT/CRITICAL REVIEW COMMENTS	Page/¶ Para#	Elec Copy/Hard Copy
278 ADB257273	DTIC	Aug 00	Development of a Multi-Purpose Airlock for the Chemically/Biologically Hardened Air-Transportable Hospital	Blewett, William K	AFRL/MLQL Note: Test and Eval parameters and data which may be useful to modelers Pages 23 – 29 of PDF. Tables 1 – 3 have hard data: ¶ **Conclusions: Fan Pressurization Testing** – with leakage rate of airlock makeup flow greater than 400 cfm required for pressurization to 0.3 iwg. ¶ **Conclusions: Purge Testing** – With makeup air flow rate of 400 cfm, overpressure of 0.3 iwg, and 60 hz, Airlock achieves three-log reduction in aerosol concentration in less than 3 minutes. With no makeup airflow, the airlock achieves three-log reduction in 3.6 minutes. ¶ **Conclusion: Static Vapor Challenge Testing** – Operating in the static mode (no entries and exits), the airlock provides protection factor well above the 6,667 required for collective protection shelters. ¶ **Appendix A** pages 39-83 of PDF has many engineering drawings – may be useful for CONOPS or modeling ¶ **Appendix B** pages 85-122 is Draft Operation and Maintenance manual – probably useful for CONOPS work	Pages 23 -29, 39-83, and 85-122 of PDF	E
279 13	DTIC	May 96	Development and Testing of a Medical Supply Airlock for the U.S. Air Force Chemically Hardened Air Transportable Plant	Ramos, Gabriel A; Reeves, Dennis W; Blewett, William K; Arca, Victor J; Jones, Daryl W	AFRL/MLQL Note: Vapor Challenge – Test & Eval data for Purge Rate, Protection Factor, Exit/Entry procedures. Beginning ~ Page 13 of PDF. Report addresses vapor challenge during purge test and time required to reduce aerosol concentration in medical airlock – reduce vapor challenge by 99.9% within 1 hour – max allowed purge time 3 hours. Tables 2, 3, 4, 5, and 6 contain data on direct and indirect challenge levels – airflow rate (200cfm) overpressure (0.24 wg), entry/exit purge time, etc.	Pages 13 -19, 23, and 24 of PDF	E
280 ADB175182	DTIC	May 93	Proof-of-Concept Prototype of a Medical Supply Airlock for the Chemically Hardened Air Transportable Hospital	Jones, Daryl W; Blewett, William K; Ramos, Gabriel A; Reeves, Dennis W			

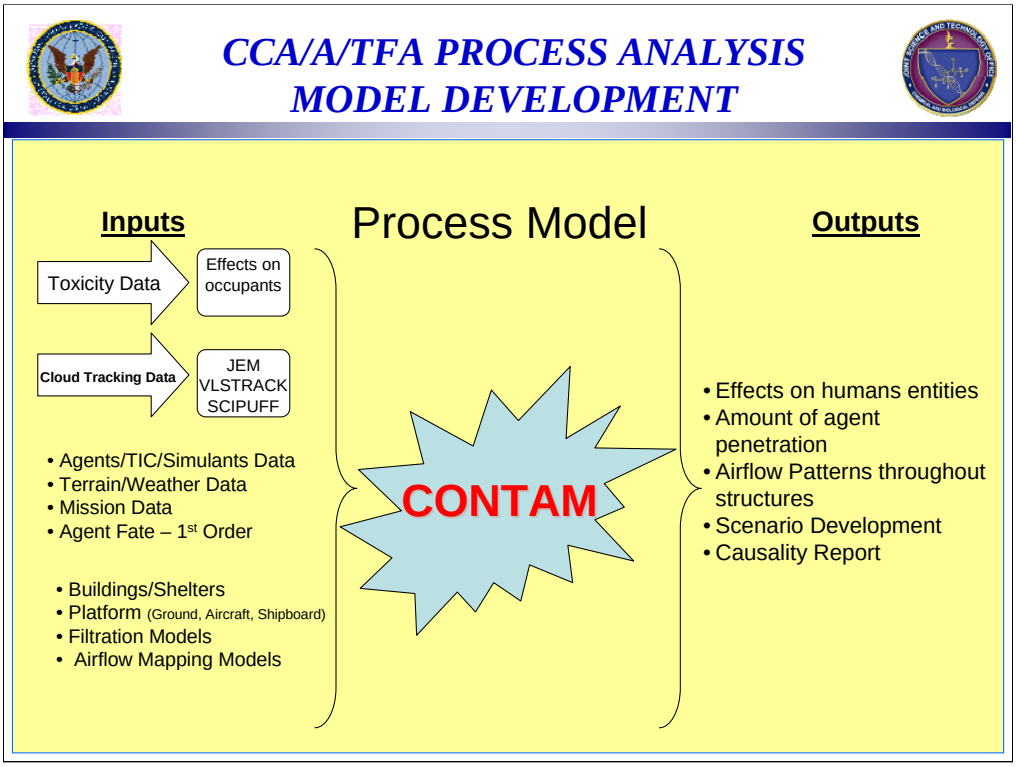
CCA-A-TFA Literature Review Process

Page/¶ Para#	Elec-Copy/Hard-Copy	CONOPS	Threat	Challenge-Level	F&T-Characteristics	Contamination-Level	Infectious-Dose-Levels	CCA-Process	CCA-Through-Put	CCA-Processing-Time	CCA-System-Specifications	Airlock-Process	Airlock-Through-Put	Airlock-Processing-Time	Airlock-System-Specifications	TFA-Process	TFA-Through-Put	TFA-Processing-Time	TFA-System-Specifications	Bullets: Ancillary-Equipment	Decontamination-Equipment	Detection-System	Modeling-and-Simulation	Test-and-Evaluation
Pages A-3; E-1, E-2	H C	X	X	X		X		X			X	X			X	X			X					
Pages A-3; E-1, E-2	H C	X	X	X		X		X			X	X			X	X			X					
Page ix; 58, 87-93	H C			X		X		X		X	X	X		X	X								X	



Next task was to develop Threat challenge information

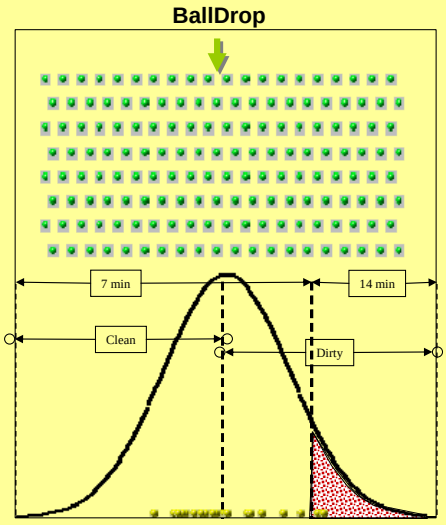
VLSTRACK was modeling tool used



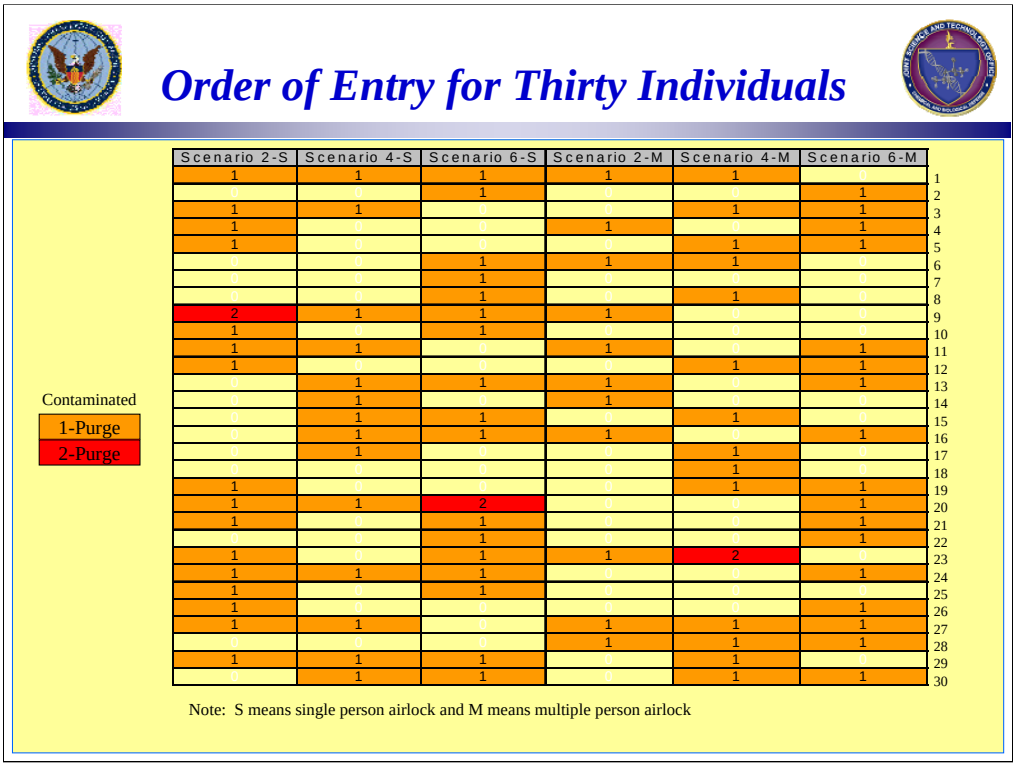
For modeling through the system CONTAM was used

Determining Who is "Dirty"

- BallDrop application for statistically/randomly determining who would make it through the CCA process "dirty"
- In this example – two are detectably dirty, seven are dirty but not detectable, 21 are clean

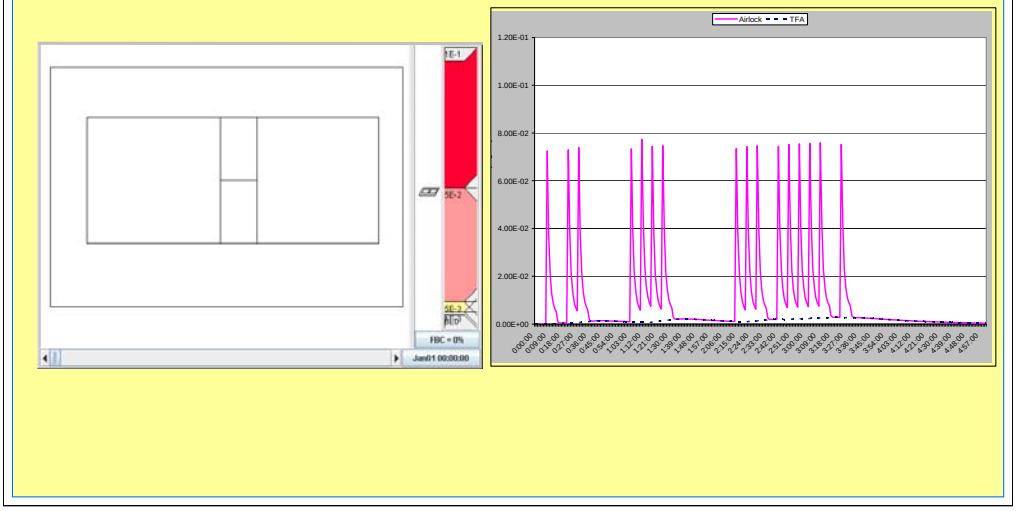


We used a random process to assign how dirty each model person was.



These are some of the scenarios and illustrates how order of entry could cause "log jams"

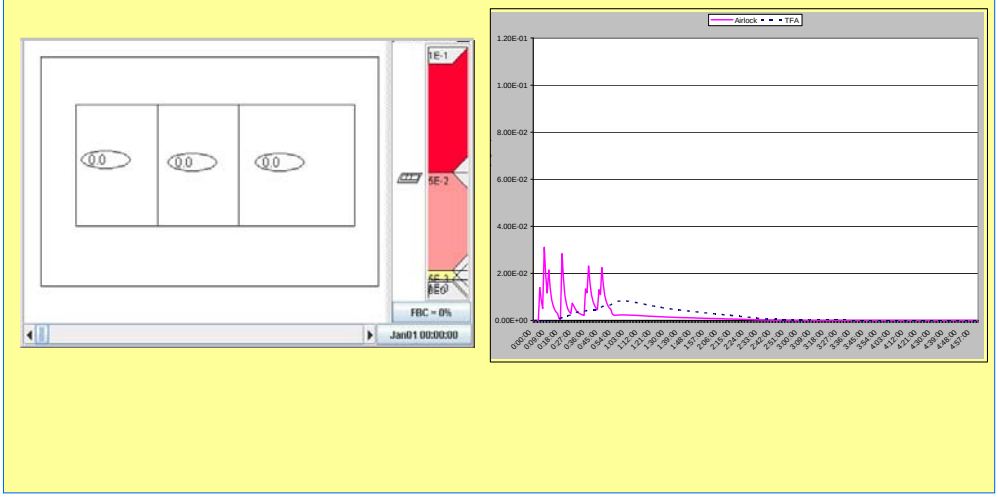
Model Results – Example Single Person Scenario 2



On left animation shows contamination concentration in CCA/A/TFA and graph on right shows concentration spikes from individuals processing through single person airlock over time.

Single person airlock maintains low concentrations in TFA but required almost four hours to process 30 individuals.

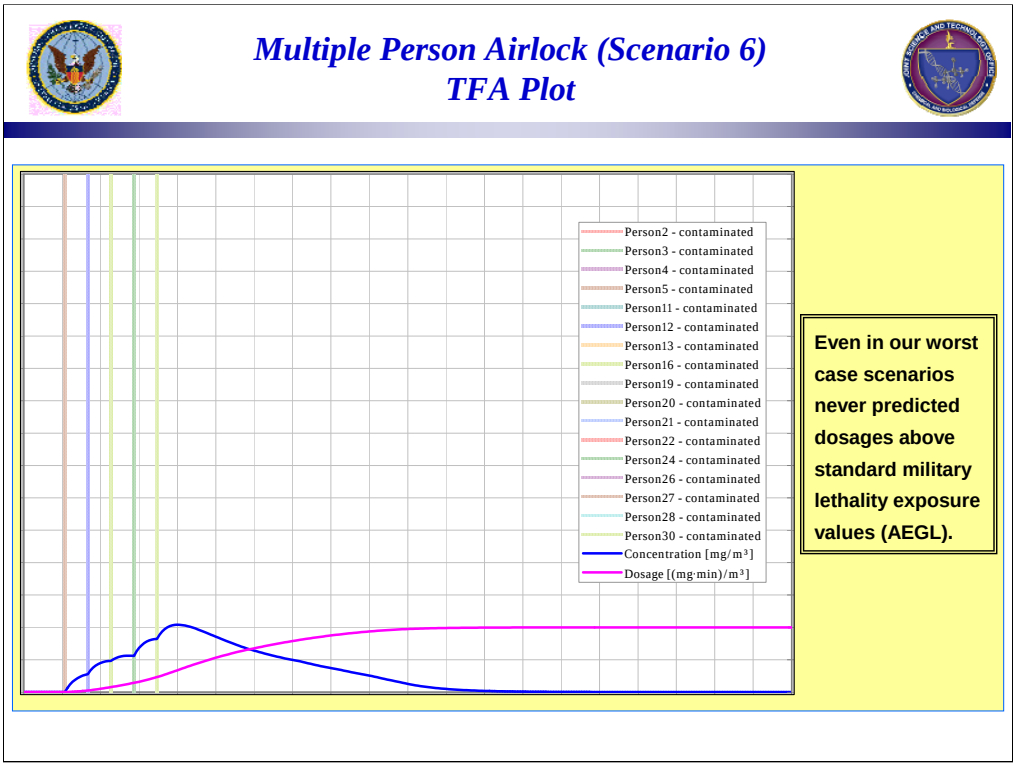
Model Results – Example
Multiple Person Scenario 6



Same type of slide but now individuals processing through multi-person airlock

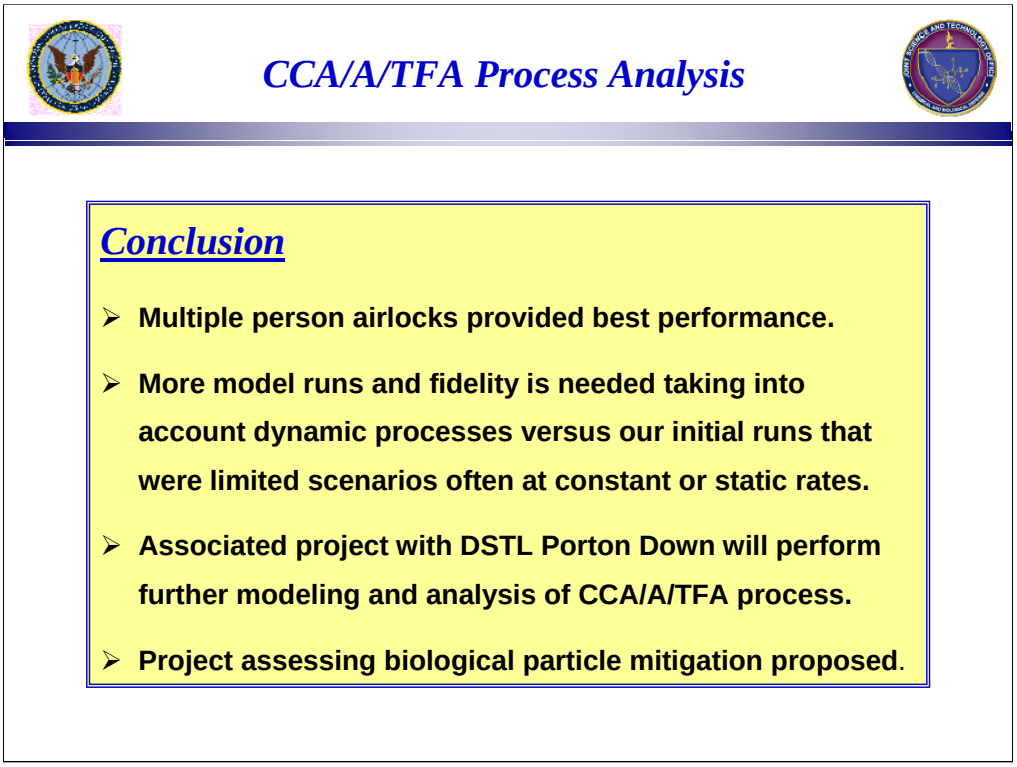
Yielded lower airlock spike concentrations but slightly higher concentrations in TFA.

However, the multi-person airlock processed all 30 individuals in less than one hour



Graph of contaminated individuals arrival time and TFA concentration and dosage.

Didn't exceed Acute Exposure Guideline Limits (AEGL).



Multi-person airlocks performed best but have logistical burden

Initial modeling provides good basis for future efforts to provide complete understanding of CCA/A/TFA Process

Thank You!